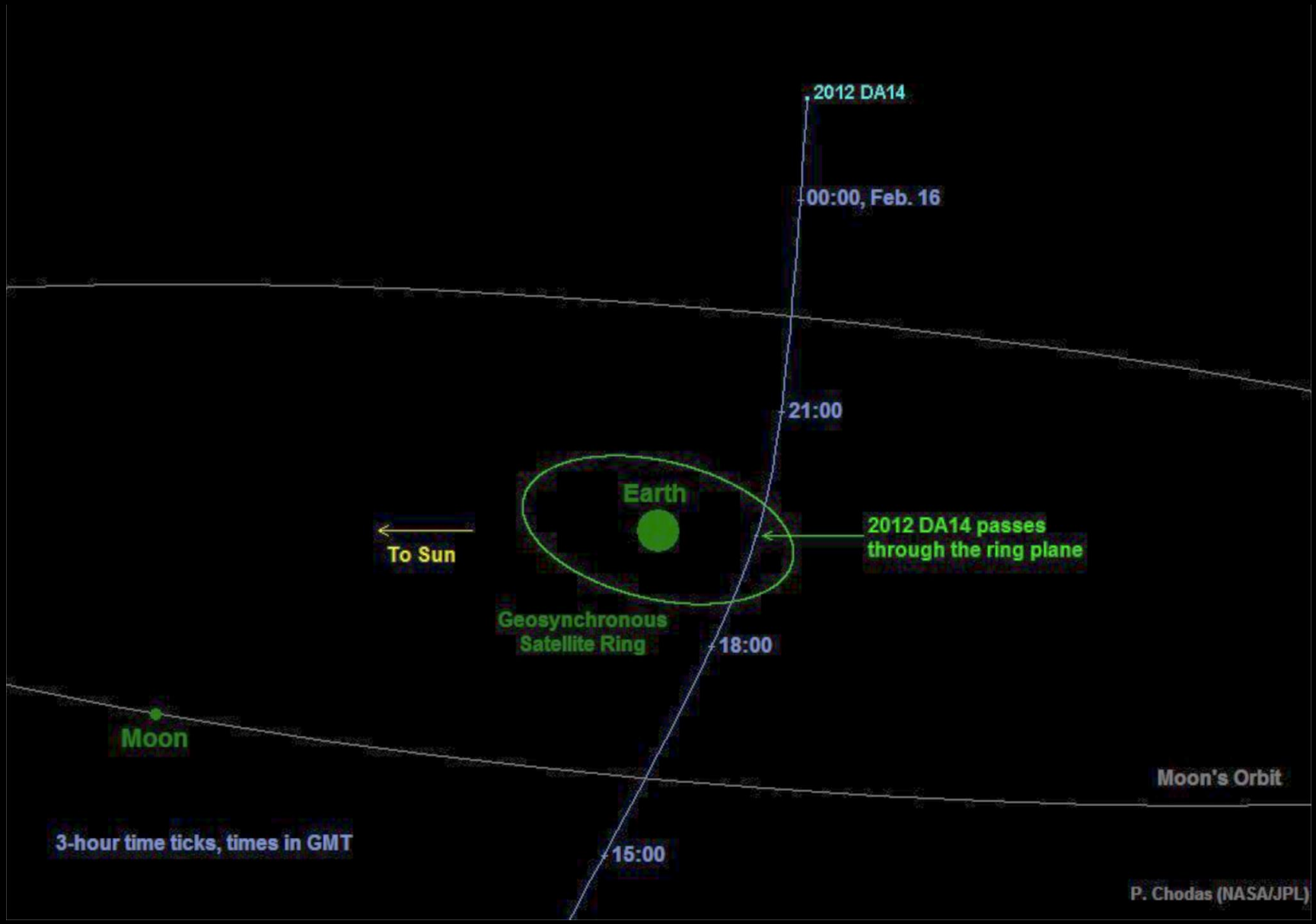
Overview of the NEO Program Office

Paul Chodas
Jet Propulsion Laboratory
California Institute of Technology

First International Workshop on Potentially Hazardous Asteroid Characterization, Atmospheric Entry and Risk Assessment
July 7-9, 2015

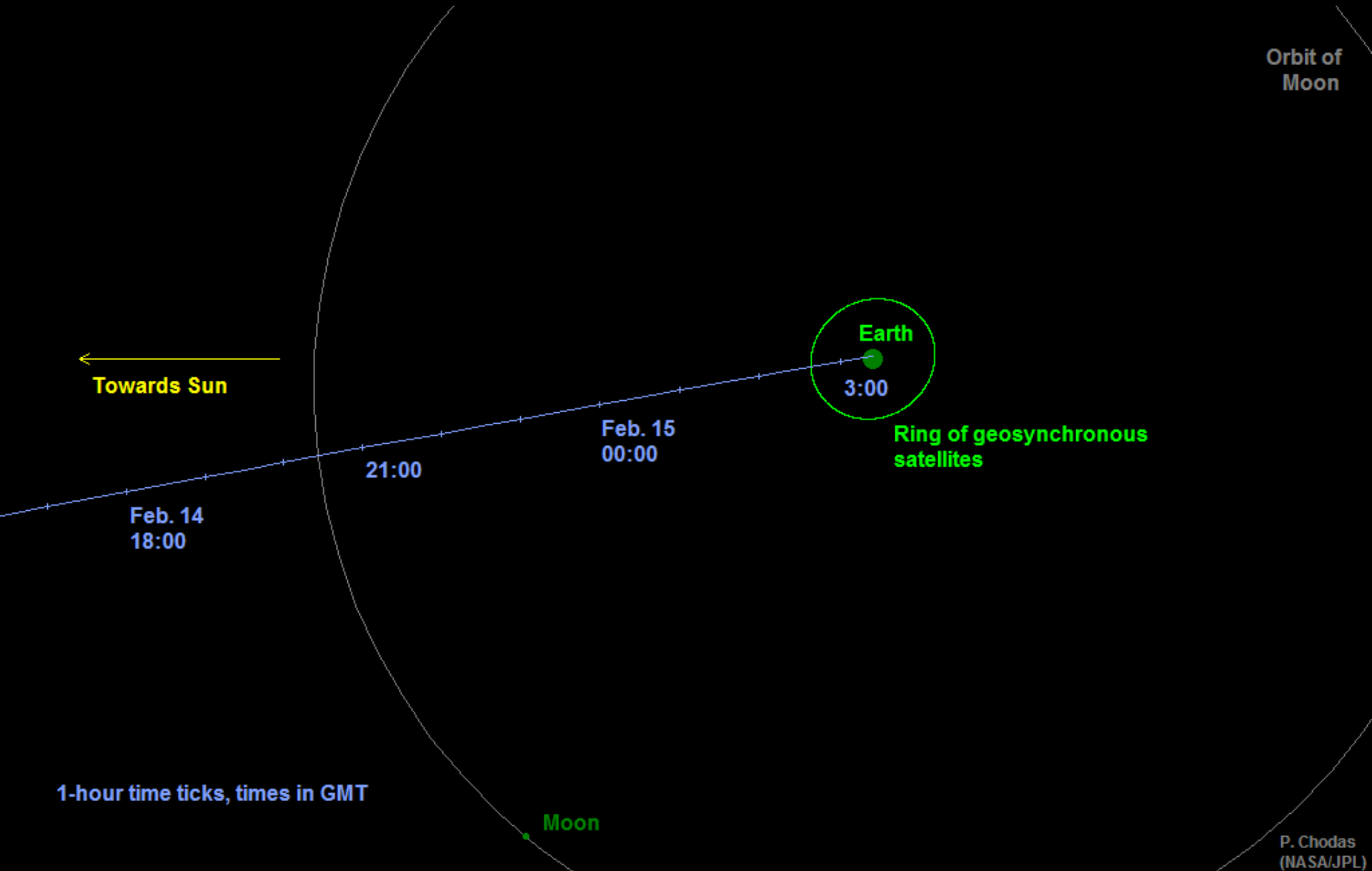
Close Approach of Asteroid 2012 DA14, Feb. 15, 2013



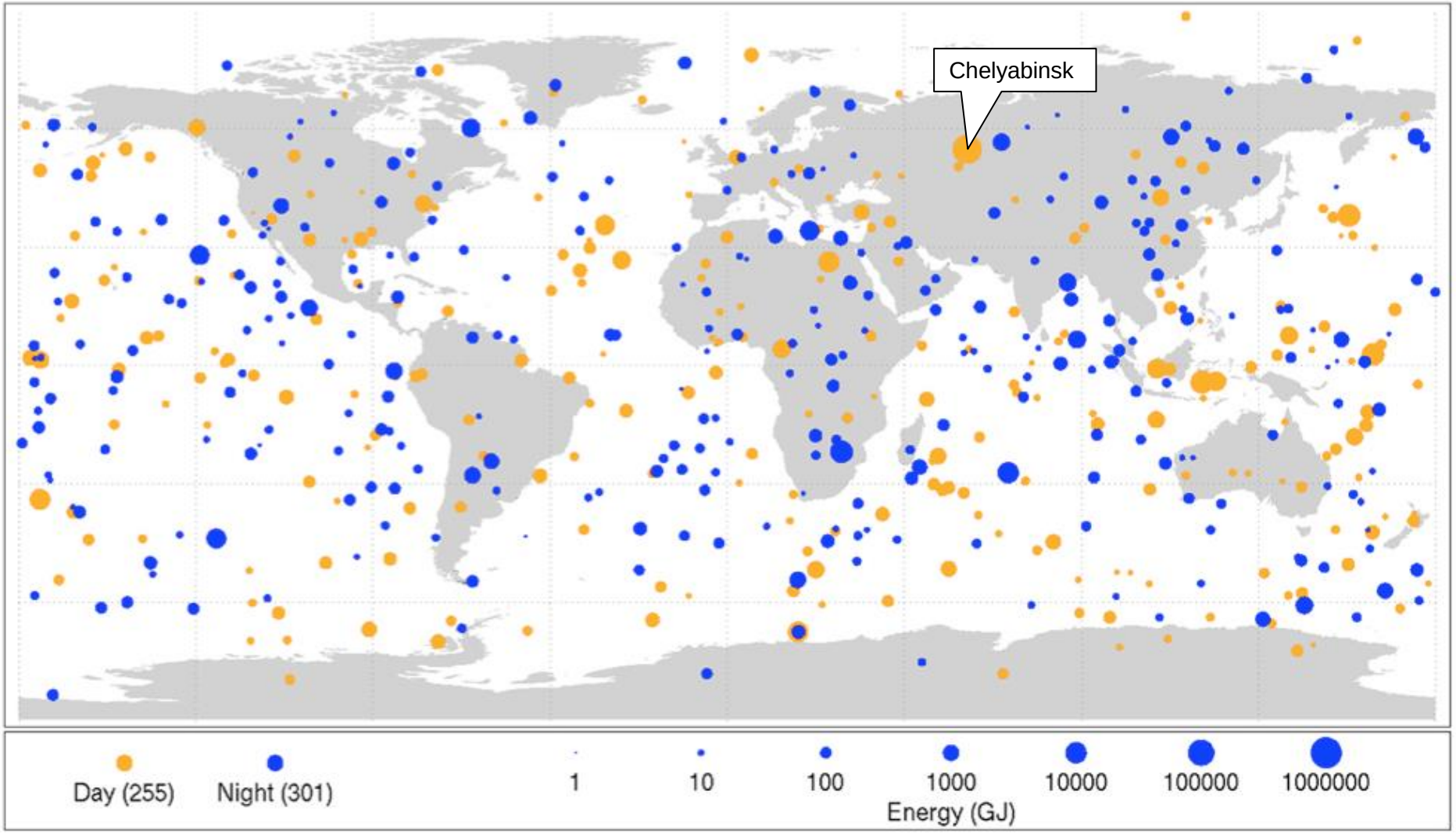
Chelyabinsk Airburst, Feb. 15, 2013

~20-meter asteroid, 500 kt of energy released at ~30 km altitude

Chelyabinsk: Final Approach Trajectory



Bolide Events 1994 - 2013

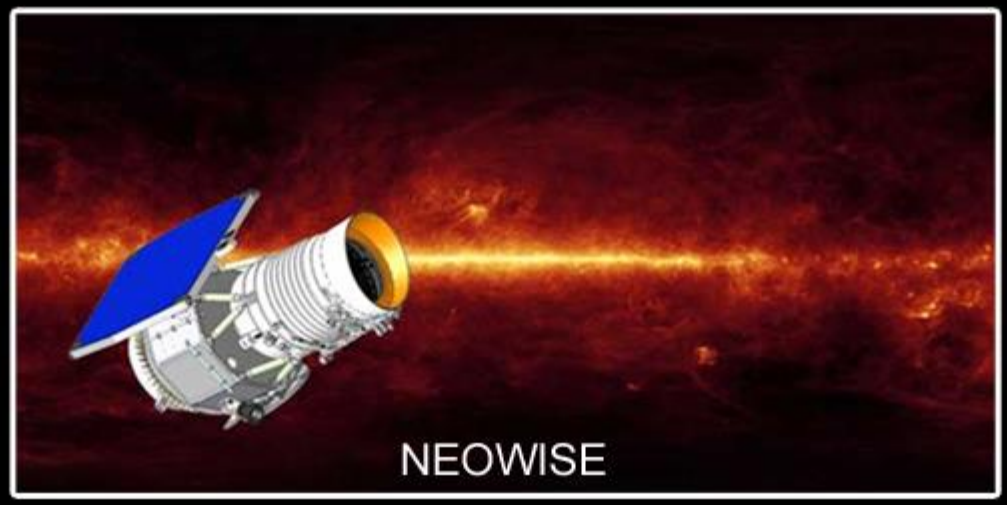


NASA's Current Asteroid Search Programs

Catalina Sky Survey

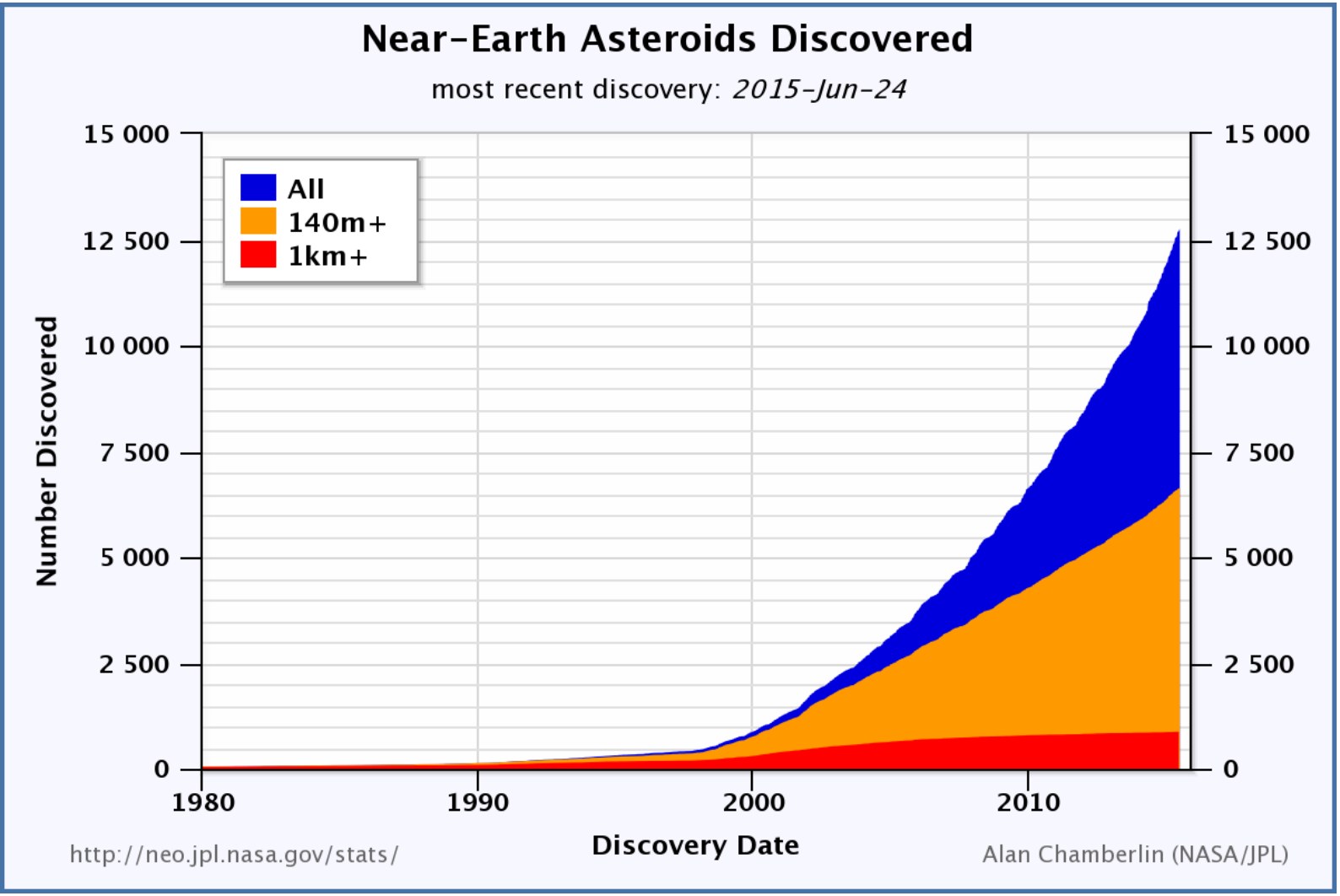
Pan-STARRS-1

DARPA Space Surveillance Telescope



NEOWISE

Number of Near-Earth Asteroids (NEAs)

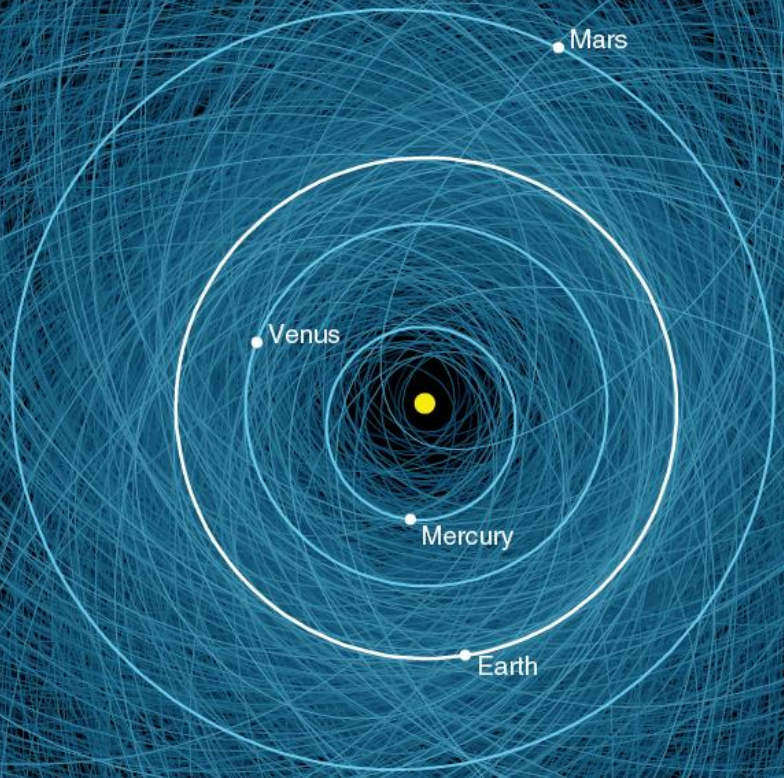


12,754 NEAs Currently Known (~1200/year)

6640 are larger than ~140m in diameter

872 are larger than ~ 1 km in diameter

1596 are Potentially Hazardous Asteroids (PHAs)

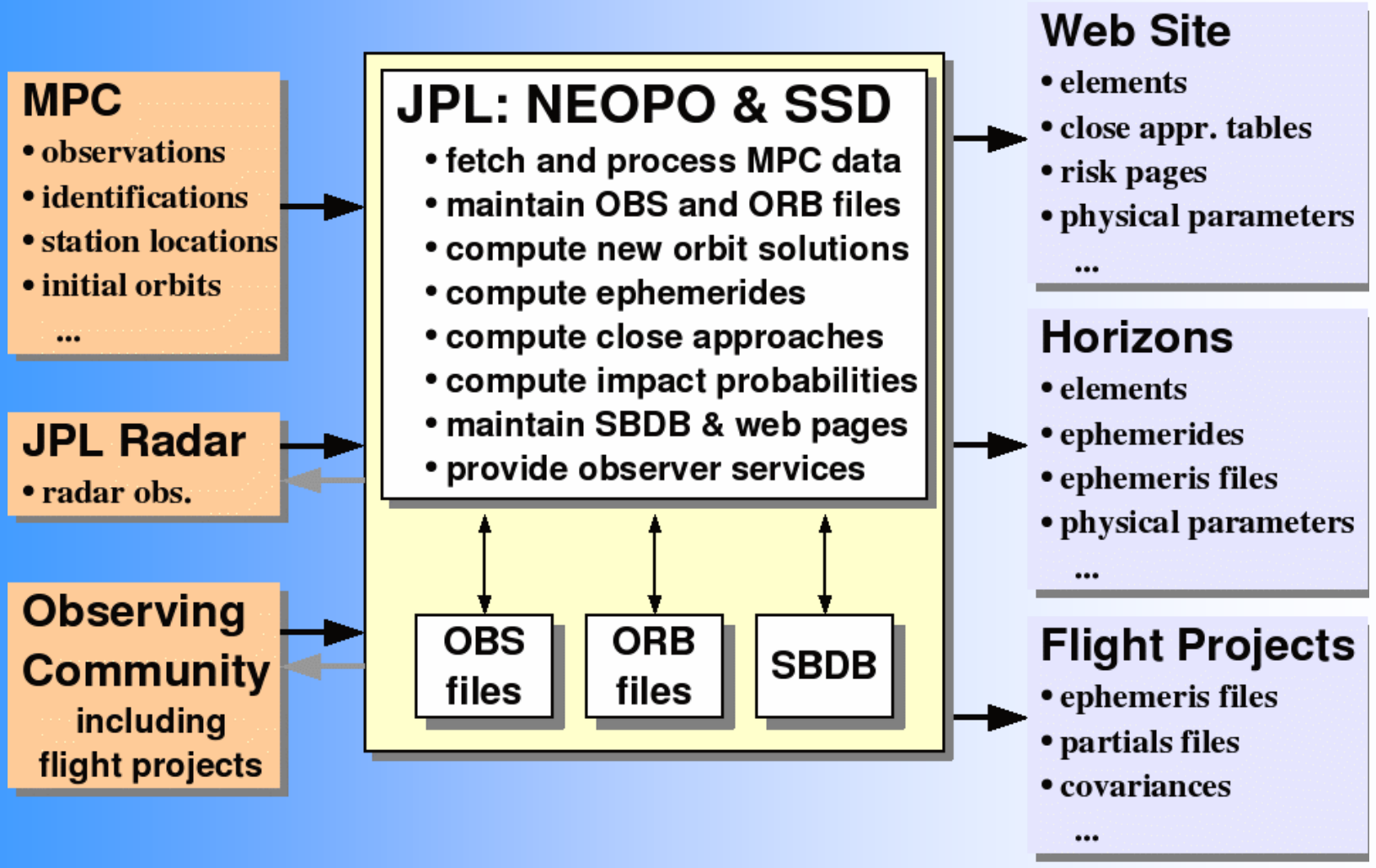


Orbits of over 1400 Potentially Hazardous Asteroids (PHAs)

NASA NEO Program Office Activities

- Compute high precision orbits for all known NEOs
- Provide high precision ephemeris computation service (Horizons)
- Maintain a Small Body Database for all asteroids and comets, with an on-line query capability
- Predict close approaches to Earth (and other planets)
- Assess potential risk of collision with Earth by computing impact probabilities over 100 years (Sentry)
- Maintain the NEO Human spaceflight Accessible Targets Study (NHATS) table
- Create hypothetical impact exercise scenarios
- Post results at http://neo.jpl.nasa.gov and http://ssd.jpl.nasa.gov

NEO Program Office Data Flow



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

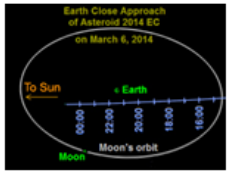
http://neo.jpl.nasa.gov

Near Earth Object Program

Jet Propulsion Laboratory
California Institute of Technology

NEO BASICS | SEARCH PROGRAMS | DISCOVERY STATISTICS | ACCESSIBLE NEAs | NEWS | FAQ

ORBIT DIAGRAMS | ORBIT ELEMENTS | CLOSE APPROACHES | IMPACT RISK | IMAGES | RELATED LINKS

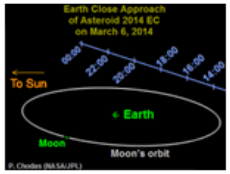


Small Asteroid 2014 EC Will Pass Earth Safely on March 6

March 6, 2014

An asteroid about 25 feet (8 meters) across will safely pass Earth at about 1:21 p.m. PST (4:21 p.m. EST) today, March 6, approaching us six times closer than the moon.

Full Story



Asteroid 2014 DX110 Will Safely Pass Closer Than Moon on March 5

March 4, 2014

As happens about 20 times a year with current detection capabilities, a known asteroid will safely pass Earth Wednesday closer than the distance from Earth to the moon.

Full Story

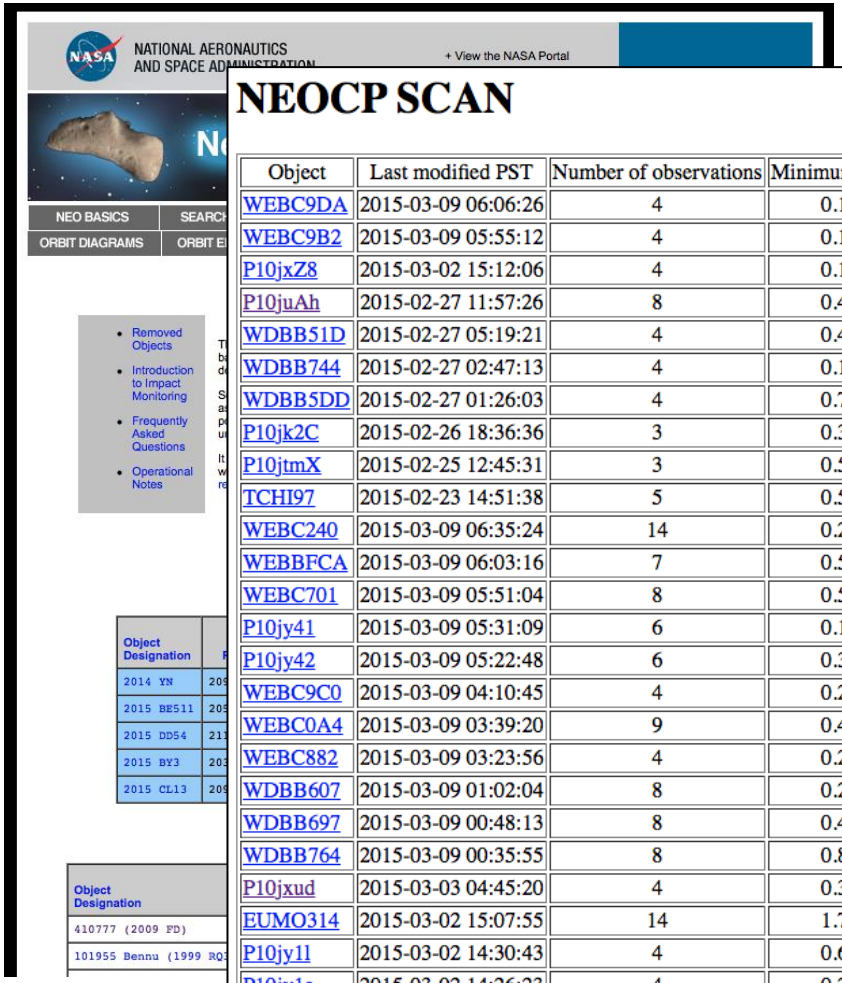
Asteroid Grand Challenge: Virtual Seminar Series

NASA is sponsoring a series of virtual seminars on the properties of Near Earth Asteroids (NEAs) and what is being done to learn more about the hazards and the opportunities they may pose for us here on Earth.

- ~~Feb 14 - David Morrison (NASA Ames & SSERVI)~~
  ~~History of impacts research and planetary defense~~
- ~~Feb 28 - Lindley Johnson (NASA Headquarters)~~
  ~~NASA's NEA programs~~
- Mar 14 - Paul Chodas (NEO Program Office at JPL)
  NEA discovery, orbit calculation and impact probability assessment
- Mar 28 - Alan Harris (JPL retired)
  NEA populations and impact frequency
- Apr 11 - Dan Britt (University of Central Florida)

Impact Monitoring Systems

- **Two systems now automated at JPL**



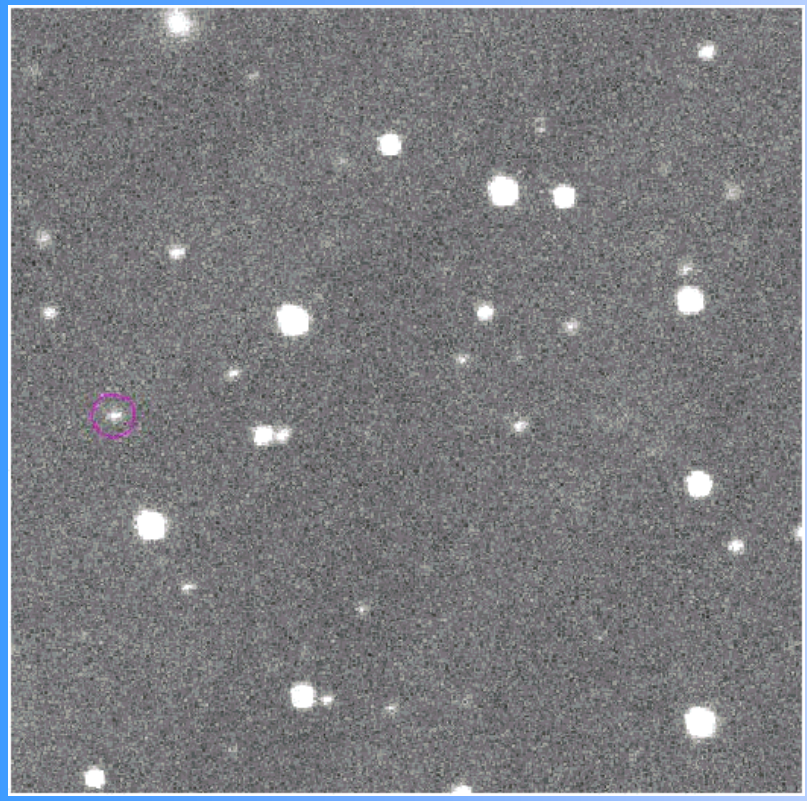
NEOCP SCAN

Object	Last modified PST	Number of observations	Minimum RMS	Impact probability	Flag
WEBC9DA	2015-03-09 06:06:26	4	0.11	1.18e-05	1
WEBC9B2	2015-03-09 05:55:12	4	0.19	2.87e-05	1
P10jxZ8	2015-03-02 15:12:06	4	0.10	1.91e-06	1
P10juAh	2015-02-27 11:57:26	8	0.47	7.70e-06	1
WDBB51D	2015-02-27 05:19:21	4	0.49	1.06e-06	1
WDBB744	2015-02-27 02:47:13	4	0.11	3.64e-05	1
WDBB5DD	2015-02-27 01:26:03	4	0.73	3.26e-06	1
P10jk2C	2015-02-26 18:36:36	3	0.34	1.49e-06	1
P10jtmX	2015-02-25 12:45:31	3	0.55	4.05e-06	1
TCHI97	2015-02-23 14:51:38	5	0.54	5.07e-06	1
WEBC240	2015-03-09 06:35:24	14	0.25	0.00e+00	0
WEBBFCA	2015-03-09 06:03:16	7	0.53	0.00e+00	0
WEBC701	2015-03-09 05:51:04	8	0.54	0.00e+00	0
P10jy41	2015-03-09 05:31:09	6	0.17	0.00e+00	0
P10jy42	2015-03-09 05:22:48	6	0.38	0.00e+00	0
WEBC9C0	2015-03-09 04:10:45	4	0.22	9.19e-11	0
WEBC0A4	2015-03-09 03:39:20	9	0.42	0.00e+00	0
WEBC882	2015-03-09 03:23:56	4	0.27	2.92e-08	0
WDBB607	2015-03-09 01:02:04	8	0.26	0.00e+00	0
WDBB697	2015-03-09 00:48:13	8	0.40	0.00e+00	0
WDBB764	2015-03-09 00:35:55	8	0.86	0.00e+00	0
P10jxud	2015-03-03 04:45:20	4	0.34	5.07e-91	0
EUMO314	2015-03-02 15:07:55	14	1.70	1.12e-11	0
P10jy1l	2015-03-02 14:30:43	4	0.62	1.10e-08	0
P10jy1a	2015-03-02 14:26:23	4	0.21	3.86e-76	0
P10jxZ9	2015-03-02 07:02:58	7	0.23	0.00e+00	0

Sentry, operating since 2002, is public and scans for potential impacts of confirmed discoveries for 100 years into the future

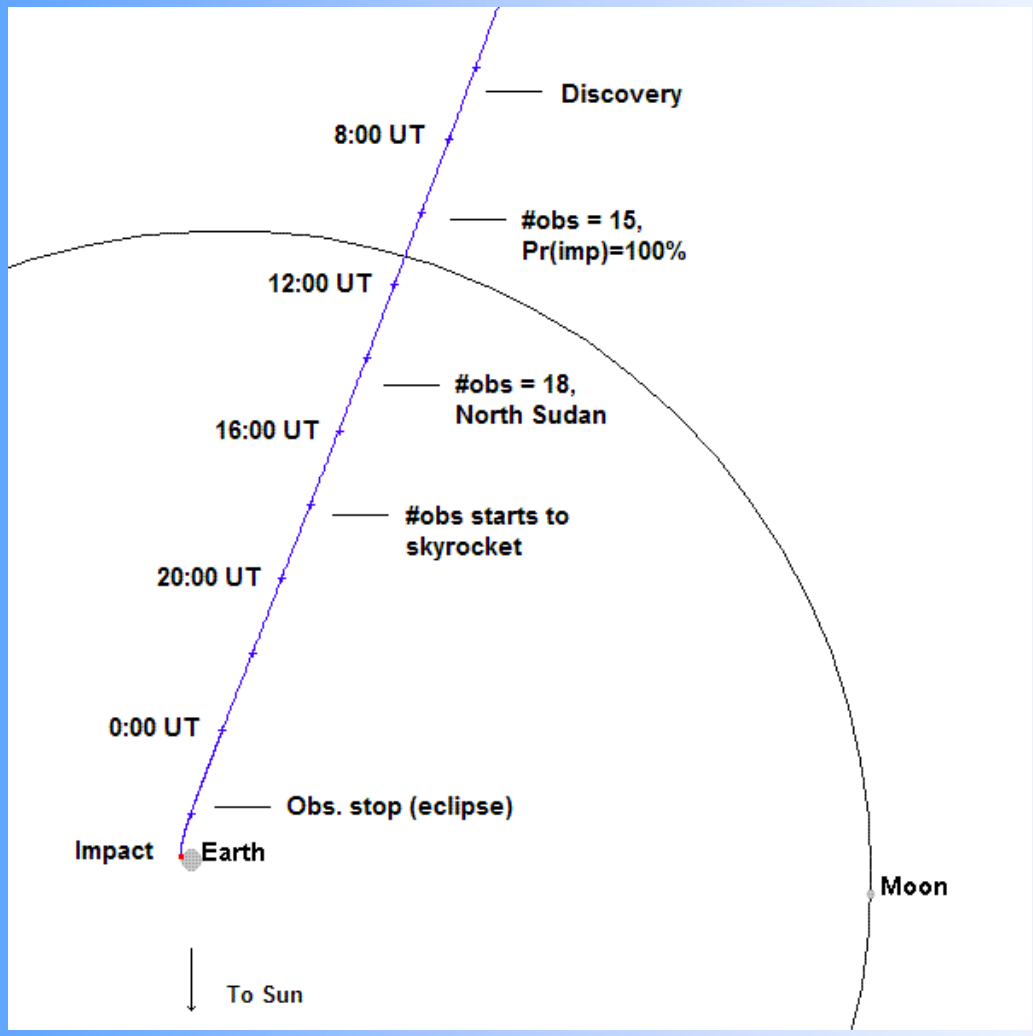
NEOCP Scan is private and scans for potential impacts of unconfirmed objects 15 days after detection

First Predicted NEA Impact: 2008 TC3

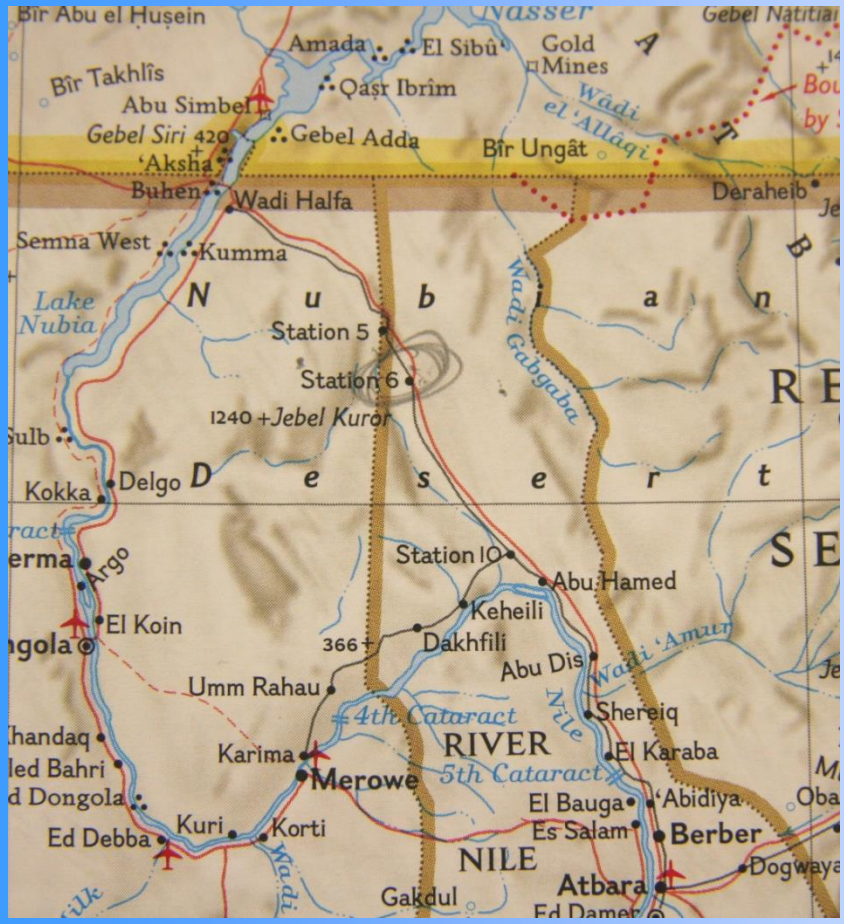


- Discovered by Catalina Sky Survey at 1.25 LD, 19 hr before impact
- Within ~5 hrs, routine processing at Minor Planet Center determined that an impact was likely; MPC contacted JPL and NASA HQ
- The object was clearly very small and would likely break up on entry

2008 TC3 Timeline, Oct. 5-6, 2008

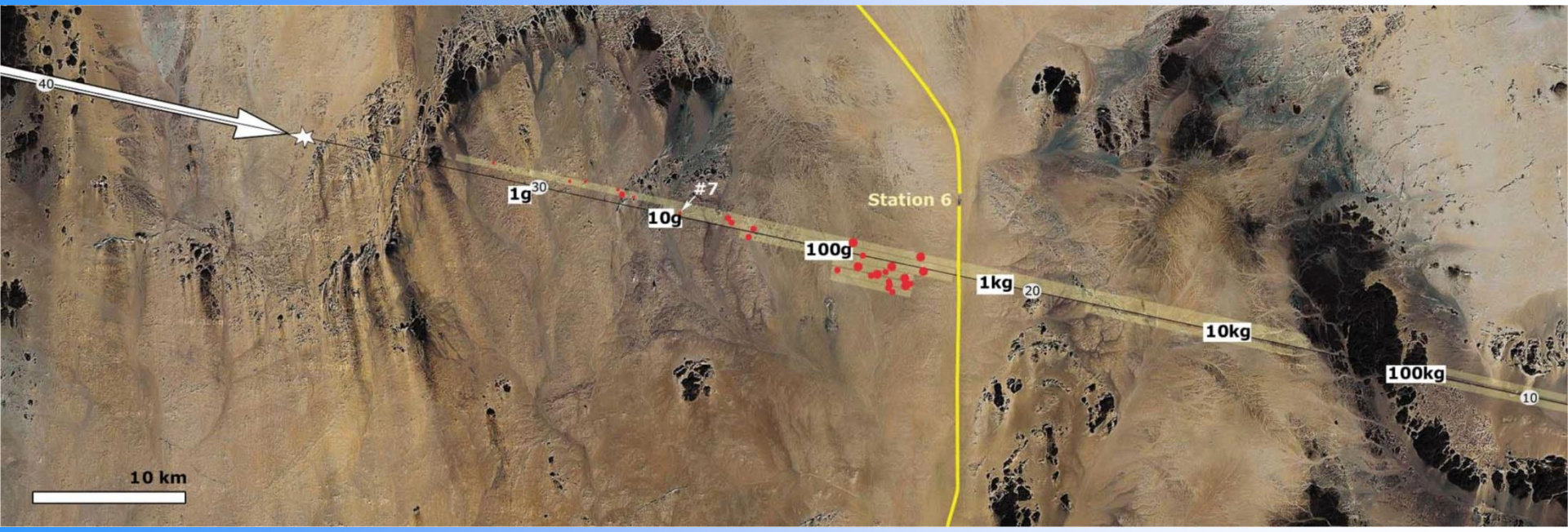


Predicted Impact Location: N. Sudan



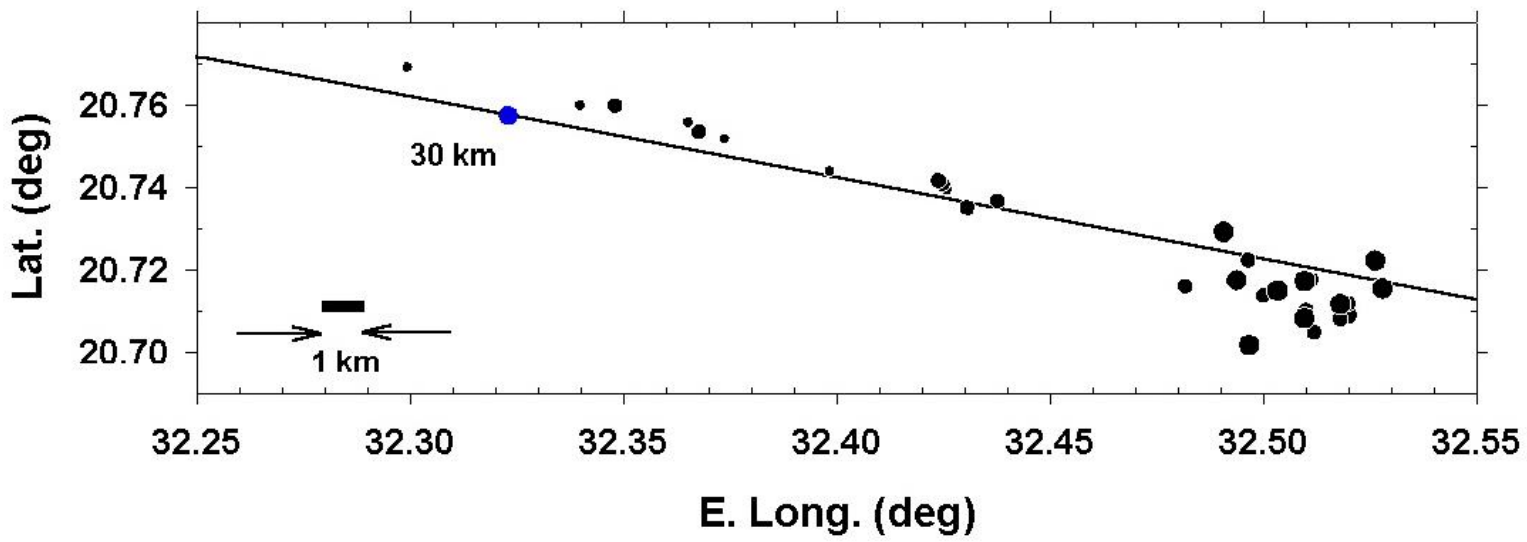
- The very first orbit solution at JPL indicated 100% probability of impact in North Sudan 11 hours before impact
- Initial 3-sigma impact ellipse major and minor axes: 64 x 6 km
- Later, impact ellipse shrank to 3 x 0.3km
- Impact at a low elevation angle
- What altitude to define impact??

Impact Site in N. Sudan



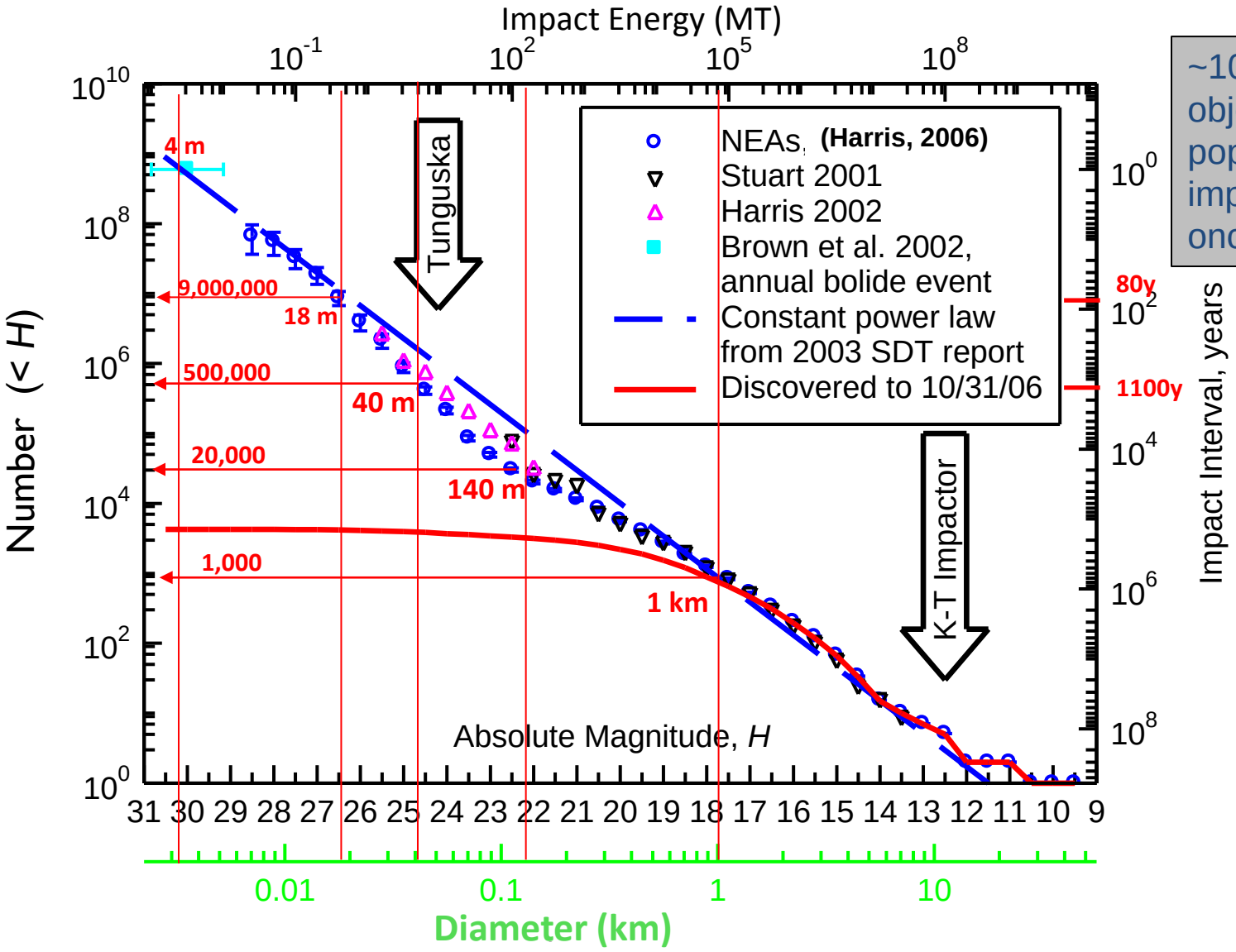
(from Jenniskens et al. *Nature* paper)

Ground Track & Locations of Finds



- Ground track from 2008's best reconstructed solution (#15)
- Many of the downtrack meteorite finds are 1-2 km south
- Proper inclusion of Earth J2 moves the ground track 1.3 km south

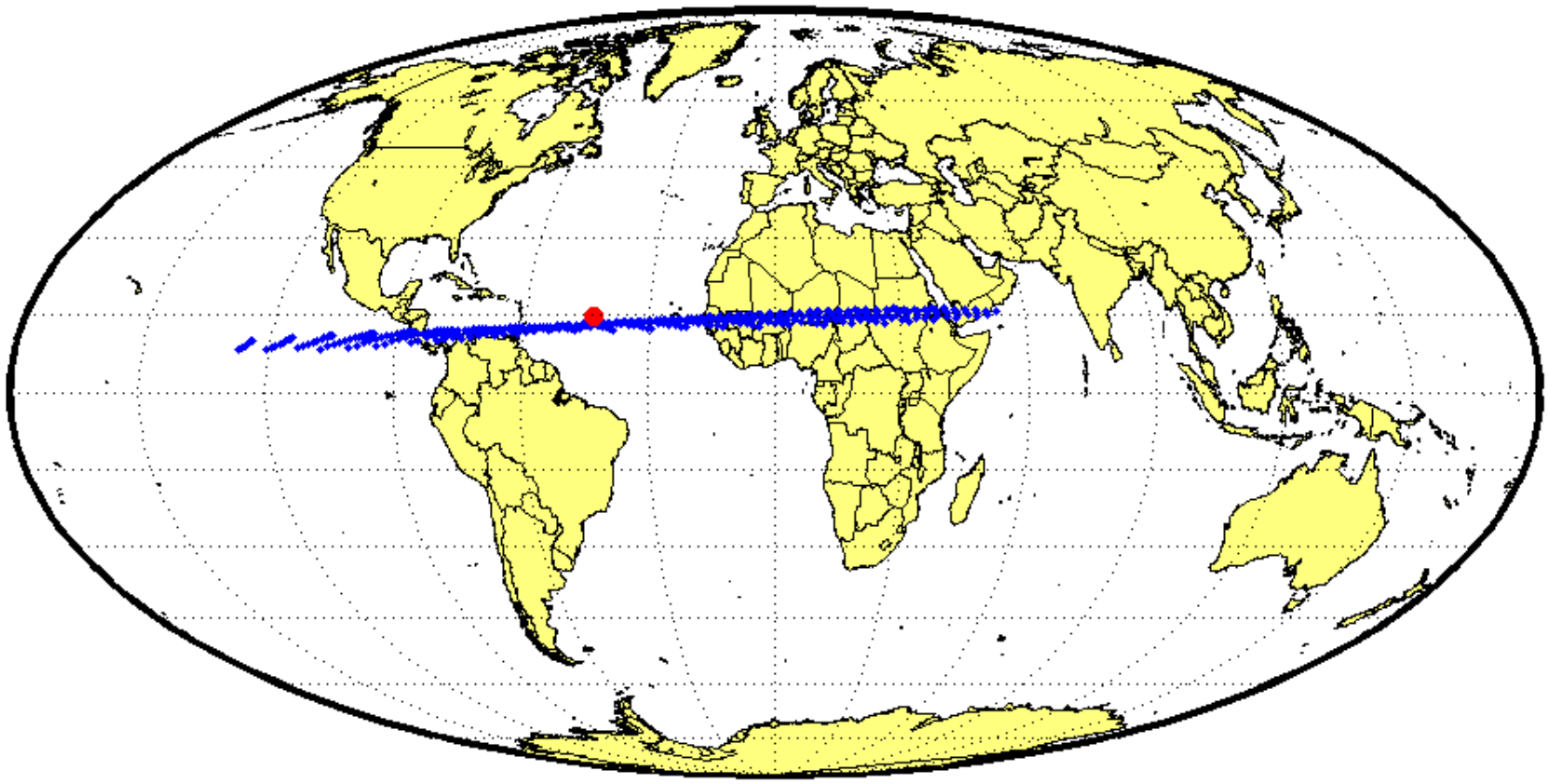
NEA Population and Impact Frequency vs. Size



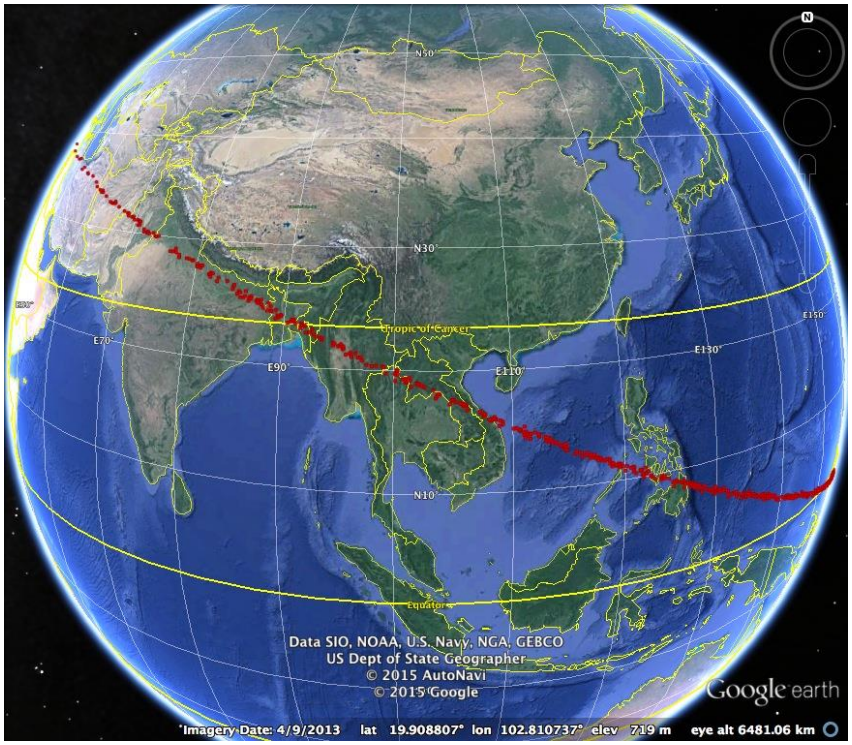
~10^9 TC3-sized objects in the population, impacting about once a year

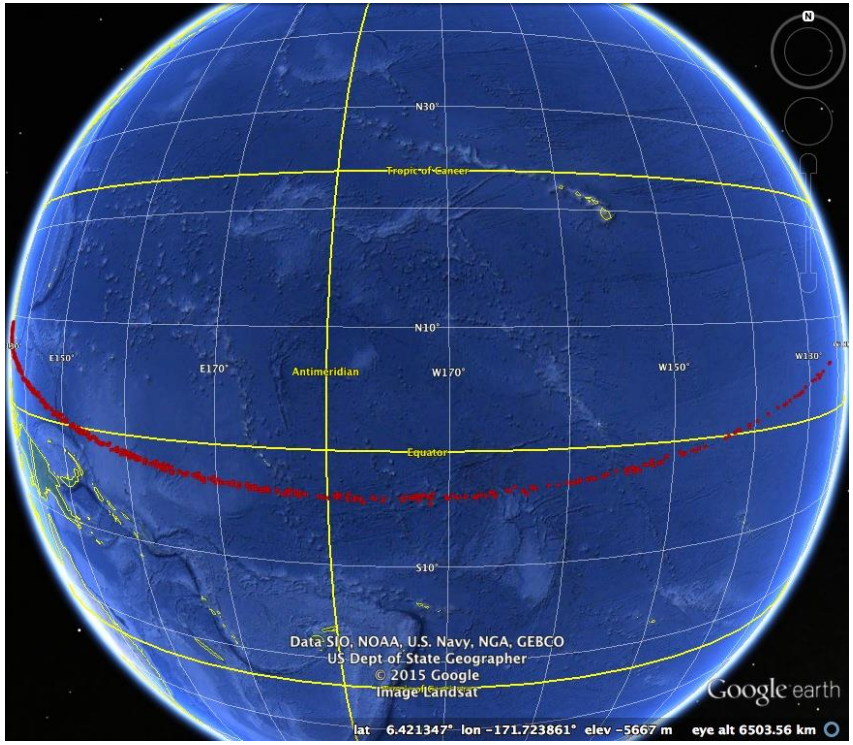
Predicted Impact Region for 2014 AA

JPL prediction shown in blue, infrasound estimate shown in red



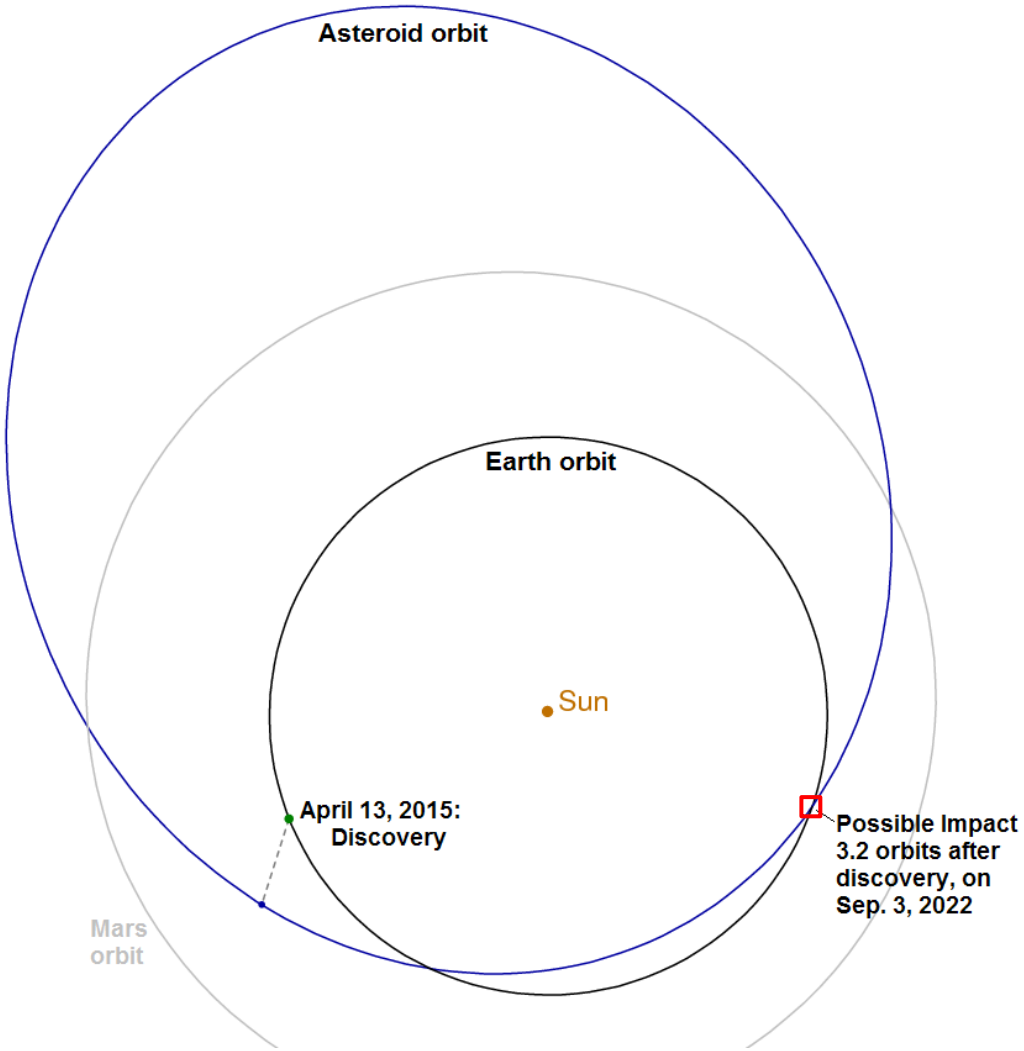
Impact Scenario for the 2015 PDC





- Discovery ~7 years before impact
- After one full year of tracking, the risk corridor still extends more than halfway around the world
- Without time for a characterization missions, the object size remains very uncertain: 150 to 400m

Orbit of Asteroid 2015 PDC

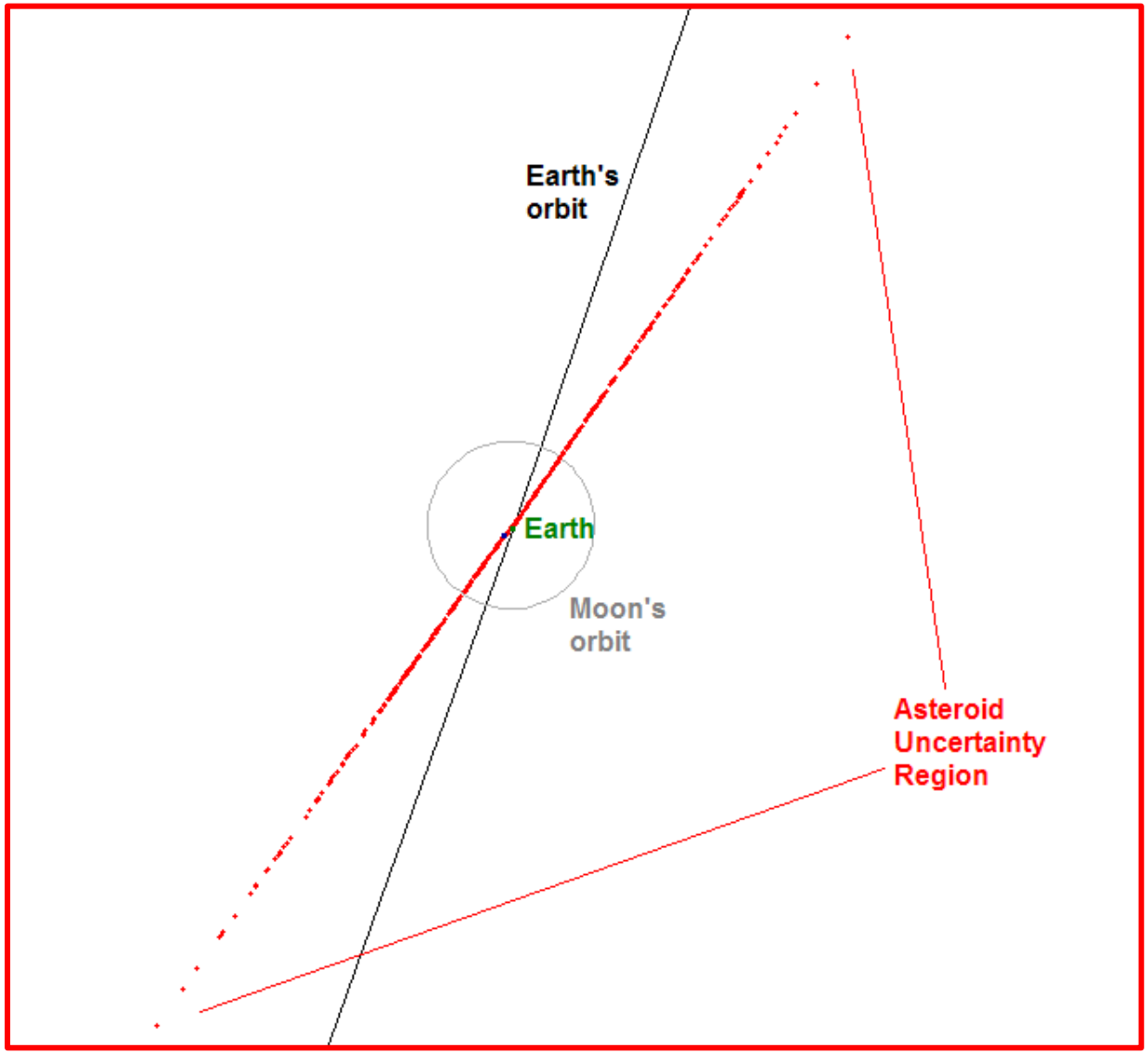


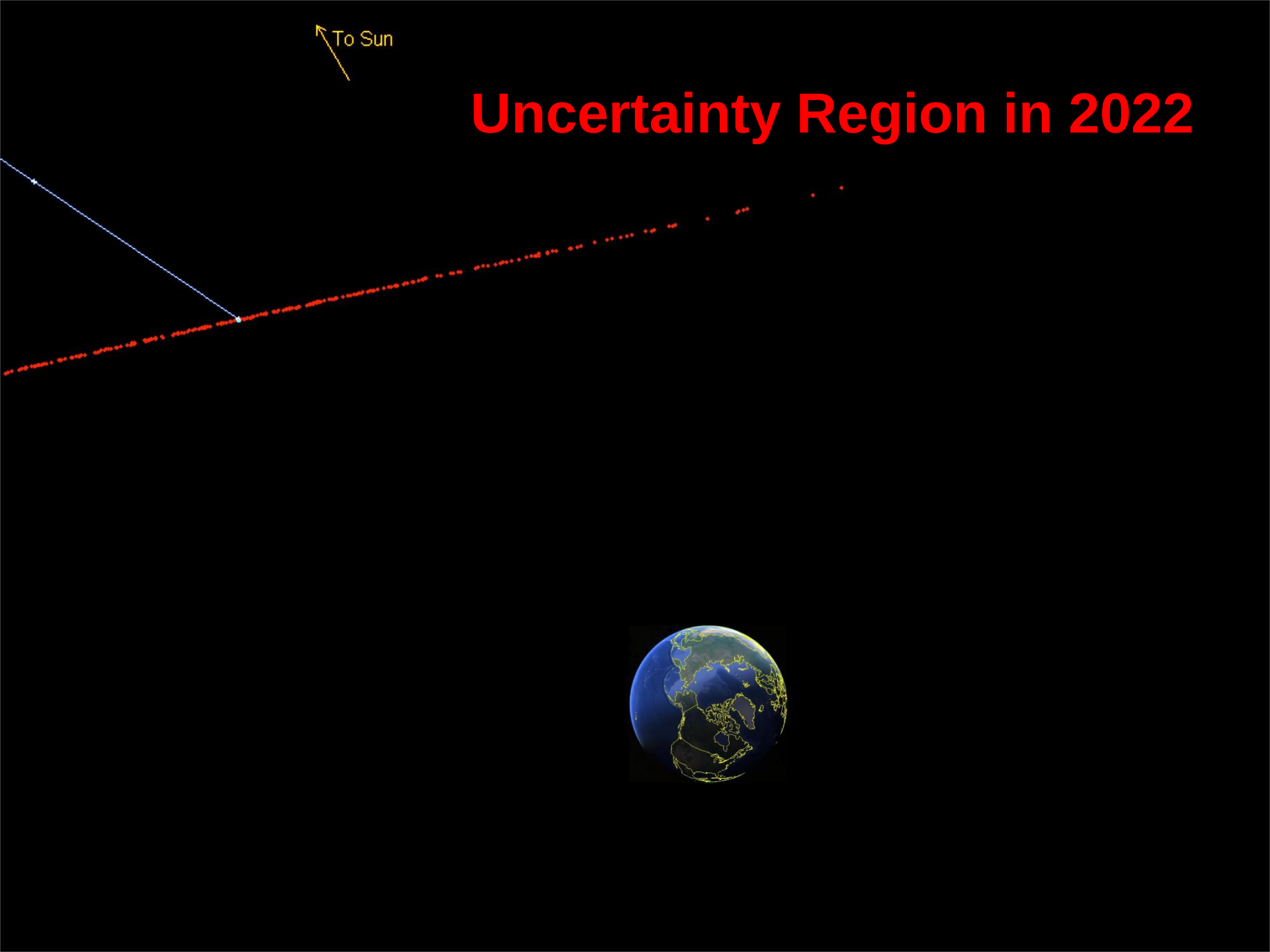
Distance from Sun varies from 0.9 AU to 2.6 AU

Orbital period is 864 days

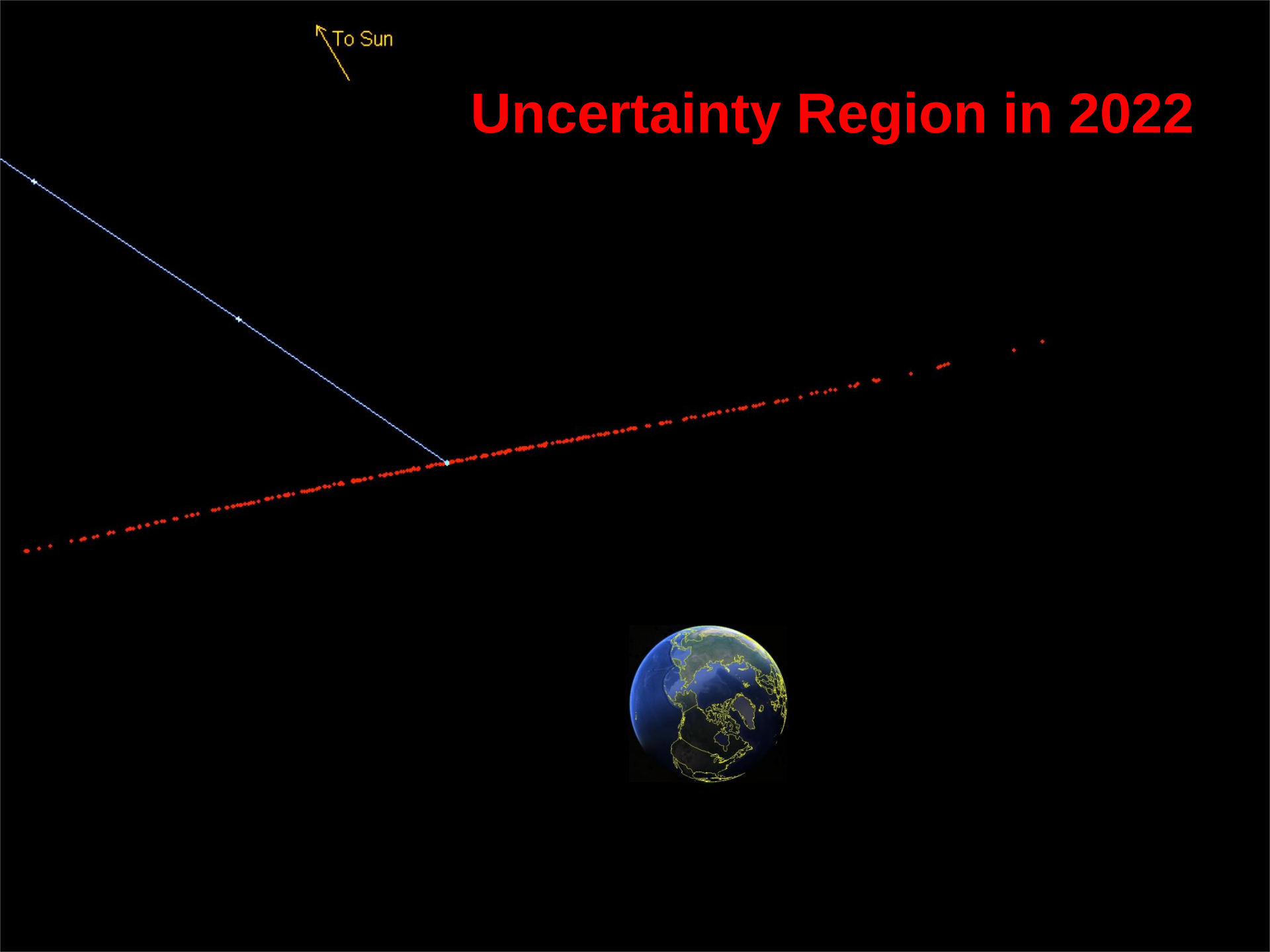
This is a Potentially Hazardous Asteroid (PHA), since the MOID is very small (0.0001 AU)

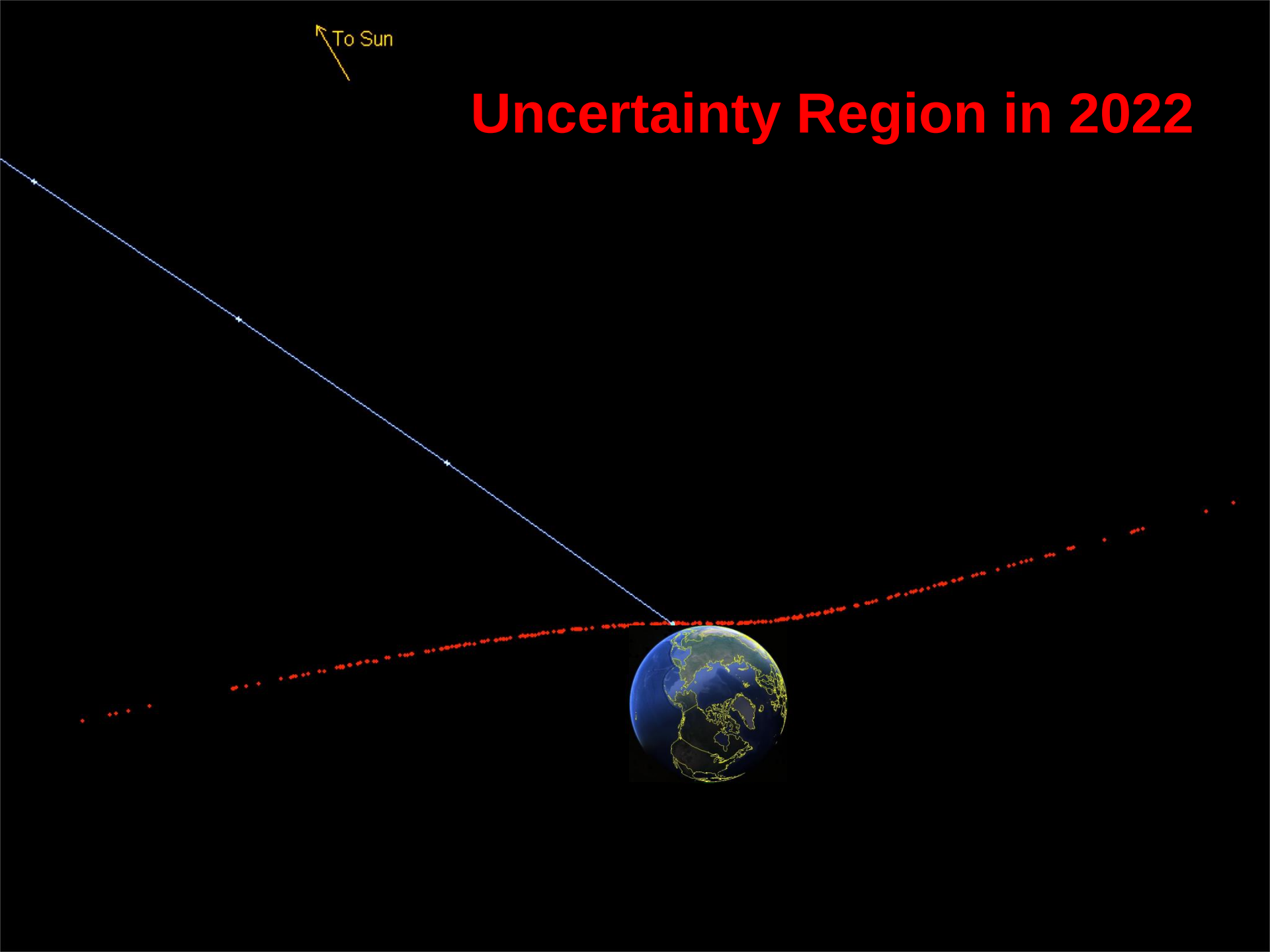
Current Position Uncertainty in 2022



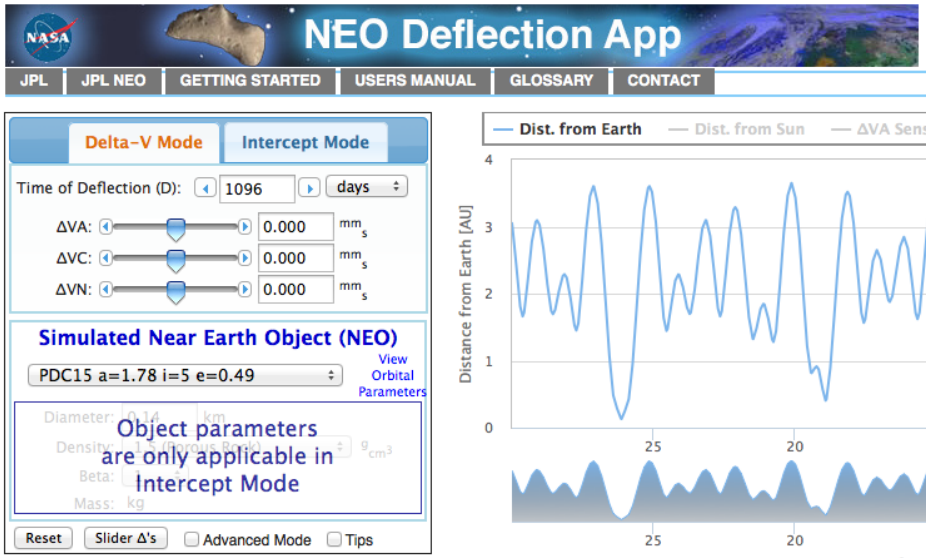


Uncertainty Region in 2022


To Sun
Uncertainty Region in 2022


To Sun
Uncertainty Region in 2022

Design Your Own Deflection Mission



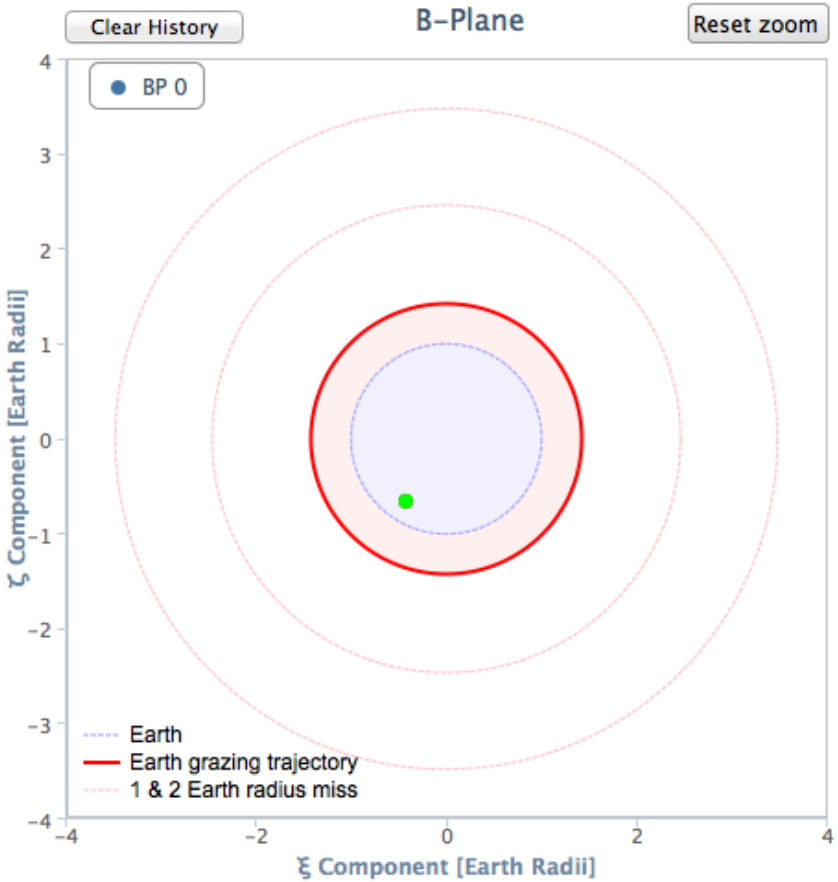
http://neo.jpl.nasa.gov/nda

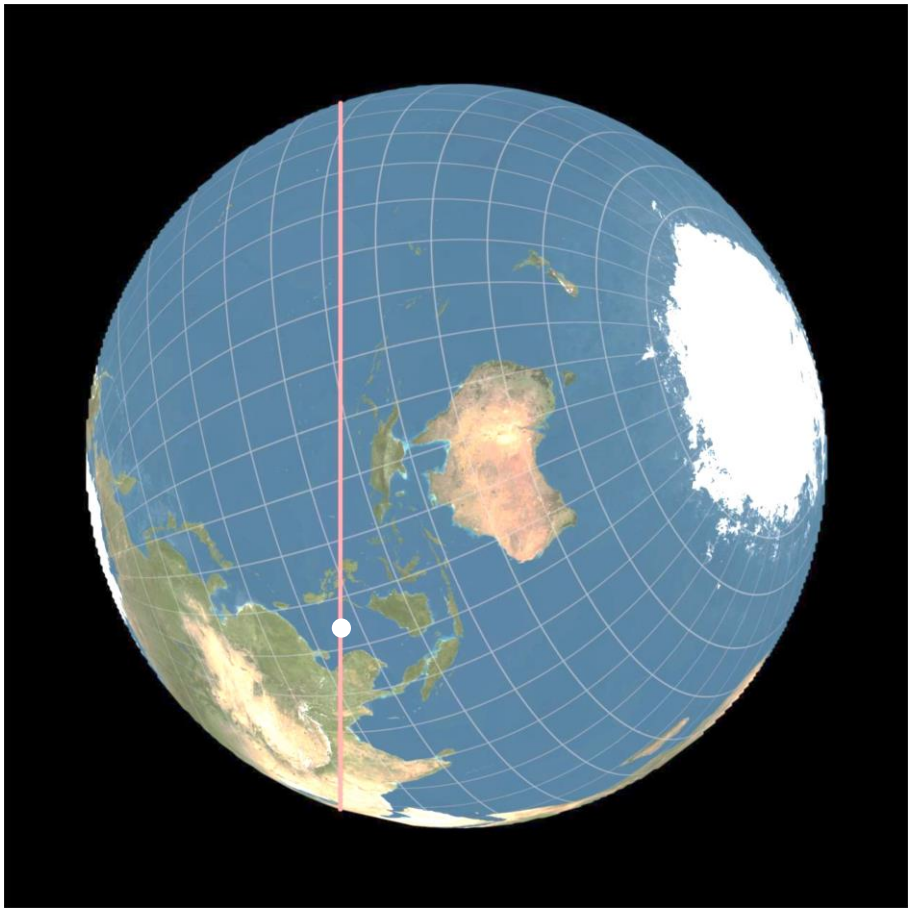
Read overview

Start the app

Take a tour of the app using the 2015 PDC scenario

Updated Nominal Impact Trajectory





Updated Risk Corridor for PDC Fragment

Impact Footprint Several Months Before Impact